Real-Time Tragedies: A Simulated "Commons Learning Laboratory"

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ABSTRACT

"Commons-type" computer simulations are increasingly popular tools for helping students grasp the underlying trap of individual versus collective rational action in situations of joint ownership and finite resources. Historically, these simulations have been designed on mainframe or mini computers with site limited capacity for either visual or auditory feedback. This paper presents a preliminary commons-type game designed for use with the emerging local and extended-area MacIntosh based networks. This paper also tests whether providing diagrammatic and verbal descriptions of the inherent resource and behavioral feedbacks enables players to avoid the fundamental commons trap: Short-term individually rational actions which result in collectively irrational consequences.

The "Tragedy of the Commons" is a situation in which a renewable resource becomes depleted through continued harvesting by some number of exploiters acting individually and/or collectively. As originally conceived by Hardin (1968), this class of problems focuses on a jointly owned "common pasture" to illustrate the dynamics of individual versus collective rationality. In the commons, each herdsperson seeks to maximize their gain by adding additional livestock to their herd. Since each herdsperson individually enjoys all of the gains (through the sale or slaughter of the animals) the marginal utility of each additional animal is nearly one. However, since the costs (overcrowding and overgrazing) are shared by all who use the commons, the marginal cost is only a fraction of 1. As I receive all of the benefits, yet am burdened by only a fraction of the cost, it makes sense for me to add additional cows (particularly if I believe others will reach and act on the same conclusion). The catch is that since each herdsperson is seeking to maximize utility while minimizing costs, they all reach the same conclusion. Eventually, as the herds grow, overgrazing outstrips the common's capacity to replenish itself, and the pasture is ruined.

"Commons-type" simulations are increasingly popular tools for helping students grasp the underlying trap of individual versus collective rational action in situations of joint ownership and finite resources. Several popular computer simulations prompt individuals and/or groups to separately harvest some number of chips from an apparently common replenishable pool (participants are told that they are interactively playing against some number of other actors). Since participants interact with imaginary "others", these types of games can be thought of as *partial interactive* simulations.

Concurrently, some researchers have investigated *wholly interactive* simulation effects through the use of settings based commons problems where "game masters" (instead of terminals) act as the conduit for the participants choices. A broad range of dependent and independent variables have been investigated this way, including cooperation (Rappoport, 1988; Powers & Boyle, 1983) and visibility of the resource (Cass & Edney, 1978; Powers, 1986).

Since the dilemma faced by individuals in a commons group relates to short-term selfish consumption versus long-term collective conservation, issues of cooperative action are essential to understanding both the causes and solutions of commons problems. In particular, our understanding of others' behaviors influence our decision to cooperate or act in a self-interested manner.

A FEEDBACK VIEW OF THE COMMONS

Three essential feedback pressures are operating in the commons context: 1) Others' behaviors influence our decision to cooperate or act in a self-interested manner (and visa-versa); 2) Fluctuations in the resource size affects its ability to replenish itself; and 3) the level of resource remaining affects people's actions. Figures 1a - 1d present a sequence of causal loop diagrams representing these primary behavioral and physical feedbacks.[1] Reading from figure 1a to 1d: Taking chips increases my benefits and reduces the actual pot size (1a). Others are also taking chips, increasing their benefits, thereby further reducing the pot's size. As the pot declines its' ability to replenish itself diminishes (1b). Since benefits accrue to individuals (yet costs are jointly shared -i.e., the pot size drops), my chip taking behavior influences other's chip taking behavior and their actions influence me (1c & 1d). What was once an individually rational decision, over time becomes collectively irrational.

Figures 1a -1d about here

These diagrams expose the underlying physical and behavioral feedbacks which drive the commons to its' destruction. Can an increased understanding of these pressures prevent players from falling into the now exposed collective trap? Three primary research questions will be addressed in investigating this issue: 1) What impact will a feedback analysis of the commons trap have on the subjects behavior? 2) Do the various graphic informations help participants to better understand their own as well as others behaviors? 3) How well do actors understand the influence of the other actors, and the pot itself, on their behavior?

DESIGNING THE SIMULATION

The presented "Commons Learning Laboratory" parallels the simulations of Brewer & Kramer (1986), and others (Chapman, Hu, & Mullen, 1986) employing the partial interactive design. It differs, however, in the types of information players can access during the game to assess the commons impact. Most current simulations provide numeric game to date information about the size of the pot, the size of the players pot, and sometimes the aggregate size of the imaginary "others" pot. In an attempt to gauge whether other, more graphically based information is useful for players in understanding the commons trap, I have added three additional information sources players can access: Actual area pictures of all three pot sizes which expand and contract as play moves forward; The ability to see the past histories of the three pots (numbers representing the actual choices and effects for both real and imaginary actors on all pot sizes); and finally, the ability to graphically see the dynamics of these histories as they are plotted against time. In addition, each time the commons is destroyed, figures 1a-1d are shown in a "dissolve" designed to graphically depict the aggregated effects of player behavior on the resource.

OVERVIEW OF THE TASK

Subjects were five volunteer undergraduate business students from an introductory course in organizational behavior. All five had had exposure to the commons problem either within the context of the organizational behavior course or elsewhere in the business curriculum.

Subjects were informed that they would share access to a resource pot initially containing 200 chips. On each trail, players could accumulate from 0 to 10 chips for themselves, and that at the end of each trial the pot would replenish itself by up to 10% (However, participants were not told that there was a maximum pot size beyond which it would not continue to grow). Subjects were told that each chip they accumulated was worth $.03. However, if the common pot was destroyed (i.e., no chips remained), then each chip was worth only $.01. This price reduction was designed to mirror real the world costs of resource depletion through lost future revenues as the resource gradually looses its ability to replenish itself. Additionally, subjects were told that they could continue drawing chips as long as the pot remained

1 To help students focus on the primary behavioral feedbacks, the resource size feedbacks were left off the "feedback dissolve".

viable. Subjects were told to accumulate as many chips as possible, since this would determine how much they would be paid at the end of each session. No information was given regarding either optimal or suboptimal strategies (determining the replenishment rate -RR - and extracting 1/4 RR each round, and being greedy -extracting 10 chips each round regardless of others or the pot size,respectively).[2]

The graphic interface used is designed to allow the player several different information options to use when making their chip choices (see Display 1 for a complete display of the simulation cards). Players maneuver through the simulation via pointing to and clicking on a series of buttons. Play begins when an initial number of chips is selected and the button "Start" is clicked. During the game, the large white rectangles display darkened ellipses which represent the actual sizes of the respective pots. Numeric pot totals are also included for easy comparison. If a player wishes to see a graph of the pot sizes to that point, they can click on the button "Analyze Simulation", which takes them to the screen "Graph It" where they can either plot the information, or see it displayed in actual number histories. If the resource is depleted to the point where its ability to replenish itself is threatened, the light bulb in the button "Resource Threshold" blinks, and the computer issues a warning sound. At any time, players can get help by clicking on the "Help !!" button.

Display 1 about here

DESIGN OF THE STUDY

In addition to the group size manipulation, the level of social identity was manipulated to make salient either an individual or collective-level identification. The simulated choices for "others" varied. Round 1 decisions were greedy- for each "other" the simulation extracted the maximum 10 chips when the pot was large, with this total gradually declining as the pot declined. For this round, the aggregate "others" pot extracted between 25 and 30 chips per trial. Round 2 decisions were random so that the aggregate "others" drew between 0 and 30 chips per trial. Round 3 decisions were more mellow. The simulation adjusted its chip taking behavior according to the subjects previous trial decision using a nonlinear function to determine its actions. For this round, the aggregate "others " pot extracted between 15 and 30 chips per trial.

Each round attempts to mimic some level of social identity; greedy choices correspond to an individual-level identity where every one is extracting for themselves; random choices correspond to a low collective-level identity (it appears that some others may be acting prosocially, but their logic is undecipherable); mellow choices correspond to a moderate collective-level identity (choices are based on the subjects previous trail decisions, i.e. the subjects choices are influencing the behavior of others).

RESULTS

The primary dependent variable in this study was the number of chips subjects chose to accumulate for themselves rather than leave in the common pot. As explained, each pot destruction resulted in an opportunity to reinforce the feedbacks inherent in the commons trap. Since this relates to the primary research question of salience of information influencing future decisions, resource-decisions are analyzed both separately and across rounds.

Round 1 Decisions (Greedy conditions)

Other than their previous classroom experiences with the Tragedy of the Commons (usually

[2] Rapoport (1988) suggests that the Tragedy of the Commons has no individually optimal strategy since it is not a 2 X 2 non-zero-sum game (like the Prisoner's Dilemma). It follows then, that each Commons has a salient collectively rational strategy which depends on the group size, replenishement rate, and degree of cooperation. Therefore, the optimal strategies I discuss are game specific and are not ment to be generalizable.

through textbook reading), this round was operated under conditions of ignorance regarding the social trap of individually rational actions.

As a group, the five subjects extracted an average of 65 chips or 22 percent of total chips taken for round 1 (slightly worse than under perfect greedy conditions where pot size does not influence the simulation's calculations of "others" chip taking behavior, and expectations suggest a 25 % maximal strategy). In exit discussions, subjects indicated that during the first round their primary concern was acquiring chips. Since the others intentions appeared to be similar (almost the maximum was being extracted each trial), subjects acted to maximize their pot size. The figures in graphs A and C - of Graphs of Subjects' Behaviors & Perception - seem to support these findings.

Round 2 & Round 3 Decisions (Random & Mellow conditions,respectively)

Since all pots were quickly wiped out in the first round, players in these next two rounds were operating from conditions of limited information regarding the commons trap (through the feedback diagrams and explanations which appear whenever a pot is destroyed).

Overall, under the random social identity condition the five subjects extracted an average of 134 chips in 30 trials, or 26 percent of the total taken for this round. However, unlike play under greedy conditions, the players actions varied considerably. For example, figure 4 shows the chip plots for two subjects (and the corresponding simulated "others" pots). Subject A's own pot seems to grow at a fairly constant rate (not withstanding a short period when no chips were taken) and the "others" pot also appears to grow at a constant rate. The combination of these effects is to wipe out the pot in 21 trials, with subject A accumulating 17 percent of the total chips extracted in the round.

Conversely, subject B's own pot initially shows no growth and then seems to climb with a series of spurts interlaced with several periods of little or no chip taking. This activity resulted in an accumulated pot of 148 chips or 19 percent of the total taken for the round. However, subject B's "take none then take a bunch" strategy is 65 percent more successful than a constant harvest policy since it allowed the pot to replenish itself. Interestingly, since neither subject always took the maximum, they both displayed a type of self-sacrificing (or cooperating) behavior. It was the form of the behavior that made the difference!

Figure 2 about here

Group response to the questions indicates a more focused attention to both the pot size and the behavior of others during this round (see graphs D and F). Ironically, it was during this round that subjects felt their choices most greatly influenced the behavior of the others (graph B). This, in a situation of no simulated cooperative linkage between subjects and others!

Overall, under the Mellow social identity condition the five subjects harvested an average of 93 chips in 30 trials or just over 15 percent of the total chip harvest for the round. During this round, the influence of pot size lessened, and the influence of others' actions was at it's greatest. Combined, these findings may indicate an increased desire to sustain the pot which resulted in a largely self-sacrificing, prosocial strategy.

ACROSS ROUND RESULTS

Graphs of Subjects' Behaviors & Perceptions provides the summary information for round and question results. The number of trials increased dramatically after the Greedy round, stabilizing at just over 30 trials per round. The "others" chips per round rose steadily while the subjects chips per round rose initially only to backtrack from the Random to Mellow round. The average percentage of chips taken by the subjects can be interpreted as a crude proxy for cooperative behavior. The graph indicates that players were somewhat uncooperative during the Greedy and Random rounds, but became more cooperative during the final round.

Graphs of Subjects' Behaviors & Perceptions about here

As noted, subjects felt that their actions were most influential during the Random round. Given that participants had access to chip plots, I would have expected these perceptions during the Mellow round when simulated behavior largely mirrored subject behavior. Interestingly, the perceived "others" influence steadily increased as play continued. Also, by the Mellow round, pot size influence had diminished.

DISCUSSION

As stated, two principle interests in this study were the extent to which subjects incorporated an understanding of the social trap into their chip taking behavior and the perceived usefulness of various types of graphic information. The results suggest that the players' behavior was positively influenced by these information feedbacks in two distinct ways.

Regarding the various types of graphical information players were able to access, in exit interviews subjects mentioned the area pictures as being the most helpful, with time plots finishing a close second. Players indicated that while the accumulated pot sizes were helpful, the raw data on previous trail choices was confusing. This suggests that for commons situations a spatial rather than numeric representation of the resource is more helpful to participants (this is consistent with Powers, 1986); the ability to "see" the resource grow and shrink seems to have a powerful impact on a player's actions. Also the players' affinity for the dynamic histories of time plots may suggest that these more closely resemble the players' own recollection of previous choices than columns of raw numbers. Participants continually referred to the area pictures and time plots when making harvest choices.

In these same exit interviews, subjects felt that the verbal description of the commons trap helped them to understand that individually rational decisions were not always the most beneficial in the long run. The results seem to support this view. The subjects' actions were generally more cooperative as the game progressed, to the point of great self-sacrificing behavior during the Mellow round when the "others" influence was perceived to be greatest (to this point in the game, players had destroyed the commons twice and thus had been doublely exposed to the feedback descriptions).

Subjects were not so positive in their feelings regarding the causal diagrams that accompanied these explanations, describing them as confusing and detracting. Two subjects complained that they were unable to interpret the "+" and "-" signs in these diagrams and suggested that additional interpretive information be provided in future versions of the game. Two others suggested I drop these diagrams altogether.

All of the players indicated that the "resource threshold" warnings were effective in focusing their attention on the level of the resource itself. Its effects varied, however, across individuals. For some participants, these warnings were met with an increased chip taking vigor (a rational "maximize gains" strategy for those players who believe that the pot will exhaust itself). Others dampened their chip taking actions in an attempt to sustain the pot.

The effects of the social identity manipulation were mixed. During the Greedy round (with a simulated individual level identity), players acted from self-interested positions, accumulating chips quickly. This is generally consistent with previous research on social identity (Messick, D. M., Wilke, H., Brewer, M. B., Kramer, R. M., Zemke, P., & Lui, L.,1983; Kramer & Brewer,1984), which suggests that if players perceive others as acting from self-interest, they see the costs associated with, but not the benefits accruing from prosocial activity.

In contrast, during the Random round, with its' lack of a simulated level of identity, players believed that their actions greatly influenced the behavior of others. Ironically, when players' actions were mirrored by the simulation (during the Mellow round), the players' generally believed that their behavior had only a moderate impact on the play of other participants. In fact, several players expressed frustration over the failure of the "others" to grasp the commons trap and cooperate when they so obviously were!

In conclusion, within the limitations of this simulation (small N, bugs in the software, unvalidated survey questions, etc.), my current findings suggest first that spatial rather than numeric information is more useful for players in understanding the level of resource degradation. Second, providing an explanation of the feedbacks inherent in the commons trap appears to be effective in promoting cooperative behavior in the participants. However, as was suggested by the players, the presentation of this information may determine its effectiveness; written descriptions, rather than causal diagrams were generally cited as more interpretable. Third, knowledge of resource replenishment thresholds appears to be an effective instrument for re-focusing attention back on the resource itself. This implies that players were more focused on the actions of "others" for much of the exercise, suggesting that participants viewed the game from a "competing against others" rather than a "maximizing the resource benefits" perspective.

Future research with the "Commons Learning Laboratory" will extend the current partial interactive environment to provide for a wholly interactive extended-area-network designed to allow real-time cooperative (or otherwise) actions by several players. Also, design changes will be made to investigate the effectiveness of causal diagram versus written explanations of the commons feedback pressures.

REFERENCES

Brewer, M. B., & Kramer, R. M. (1986). Choice Behavior in Social Dilemmas: Effects of Social Identity, Group Size and Decision Framing. *Journal of Personality and Social Psychology* 50: 543-549.

Cass, R. C., & Edney, J. J. (1978). The Commons Dilemma. A Simulation testing resource visibility and territorial division. *Human Ecology* 6: 371-386.

Chapman, J., Hu, L., & Mullen, B. (1986). GROUP1 and GROUP2: BASIC programs for Laboratory Research on the Commons Dilemma and Group Persuasion. *Behavior Research Methods, Instruments, & Computers* 18: 466-467.

Hardin, G. (1968). The Tragedy of the Commons. *Science* 162: 1243-1248.

Irwin, D., Lutz, P., Moore, S. F., & Shaffer, L. S. (1988). Group Versus Individual Decision Making in the Commons Problem. *Journal of Social Psychology* 129: 551- 553

Kramer, R. M., & Brewer, M. B. (1984). Effects of group identity on resource use in a simulated commons dilemma. *Journal of Personality and Social Psychology* 46: 1044-1057

Levine, B. L. (1986). The Tragedy of the Commons and the Comedy of Community: The Commons in History. *Journal of Community Psychology* 14: 81-99.

Messick, D. M., Wilke, H., Brewer, M. B., Kramer, R. M., Zemke, P., & Lui, L. (1983). Individual adaptation and structural change as solutions to social dilemmas. *Journal of Personality and Social Psychology* 44: 294-309.

Powers, R. B. (1985). The Commons Game: Teaching Students about Social Dilemmas. *Journal of Environmental Education* 17: 4-10.

Powers, R. B., & Boyle, W. (1983). Generalization from a Commons-Dilemma Game. *Simulation & Games* 14: 253-274.

Rapoport, A. (1988). Experiments with N-Person Social Traps II. *Journal of Conflict Resolution* 32: 473-488.

Causal Feedback in a Commons Situation

Figure 1a

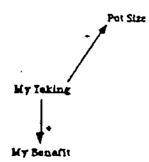


Figure 1b

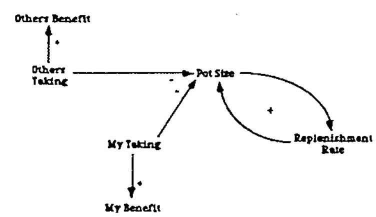


Figure 1c

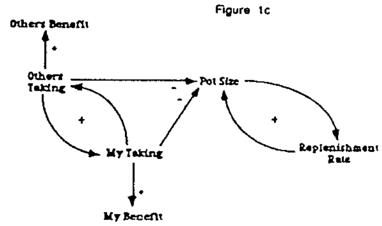
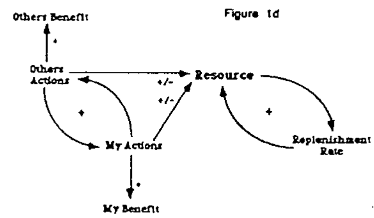
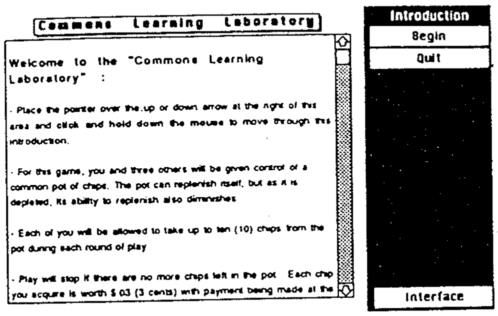
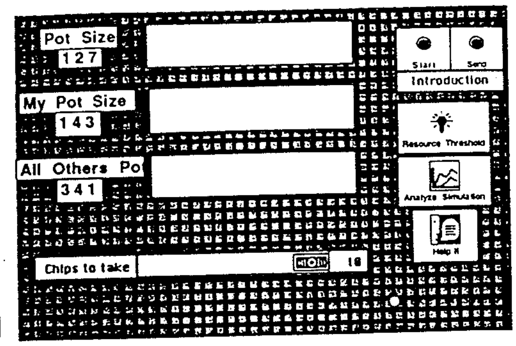


Figure 1d



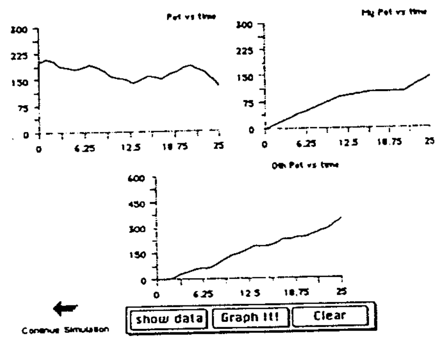




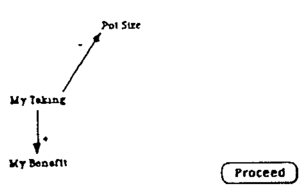
HELP !!!

- Remember, to view any of the various types of information available, simply place the hand over the appropriate button and click !! This will take you to that information
- To initiate the session, press Start
- To continue playing each additional round, press Send
- To graphically view both the behavior of other players as well as the remaining pot, press Analyze Situation
- If the pot is depleted to the point where it's ability to replenish itself is endangered, the Resource Threshold Bulb will blink and a warning will sound.

Exit Help

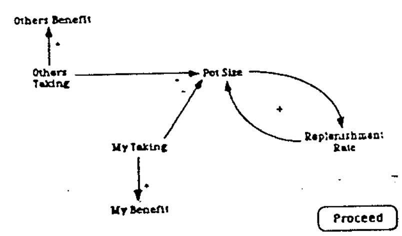


Taking chips increases your benefits. It also reduces the actual pot size .....

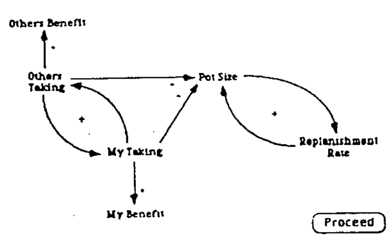


Graphs

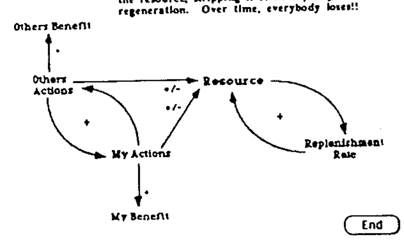
Others are also taking chips, increasing their benefits, thereby furthur reducing the pot's size. As the pot declines, its' ability to replenish itself diminishes.

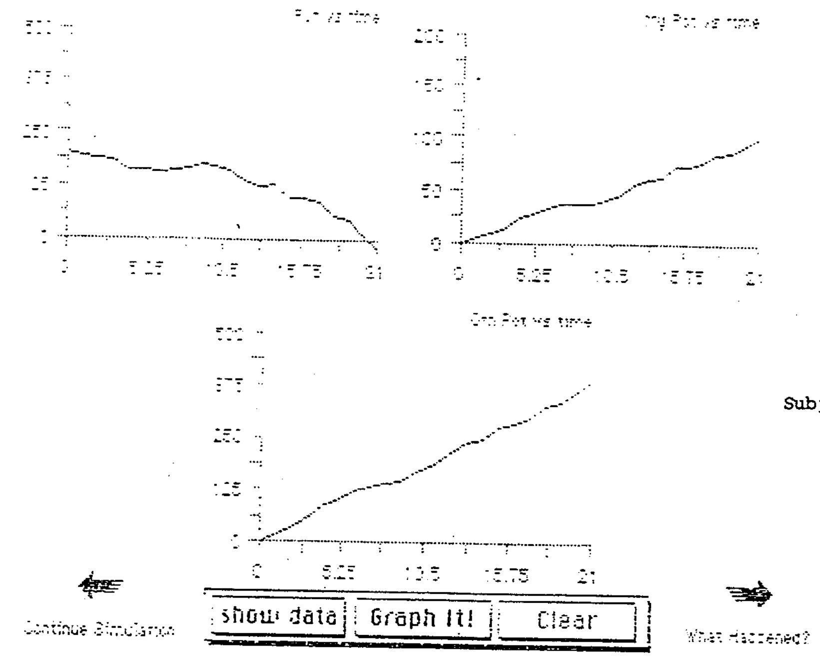


Since benefits accrue to individuals (yet costs are jointly shared -i.e., the pot size drops), your chip taking behavior influences others' chip taking behavior, and their behavior influences you. What was once an individually rational decision becomes collectively irrational:......

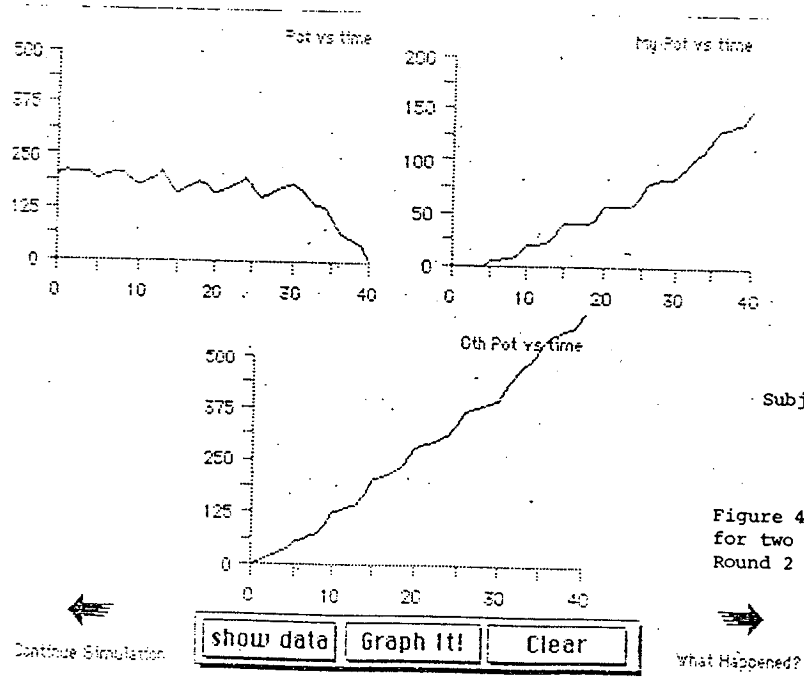


As individuals act from their own self-interest, their choices, when aggregated, quickly deplete the resource, stripping it of its capacity for regeneration. Over time, everybody loses!!



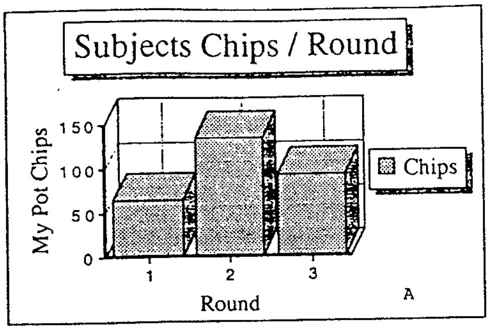


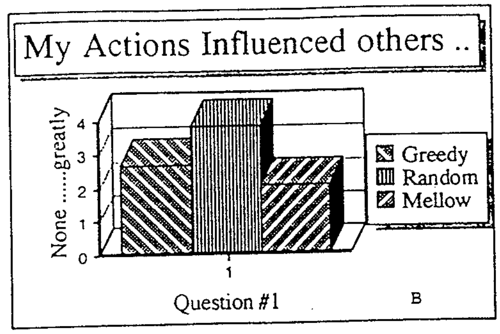
Subject A

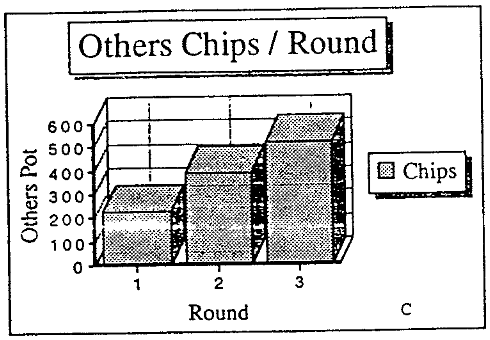


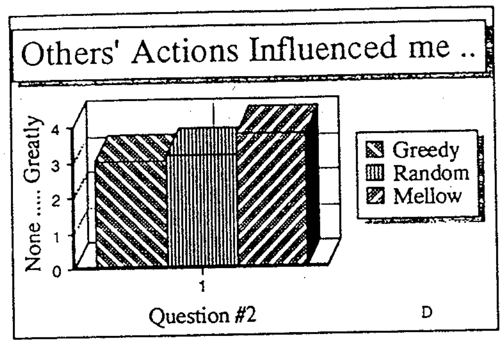
Subject B

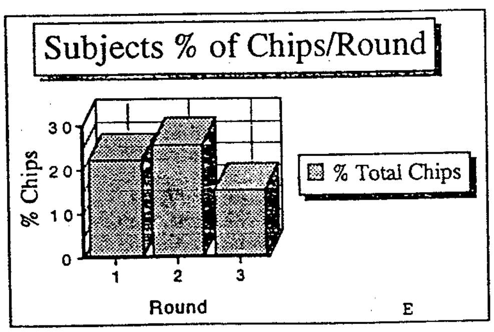
Figure 4 - Pot Plots for two subjects for Round 2 (Random)

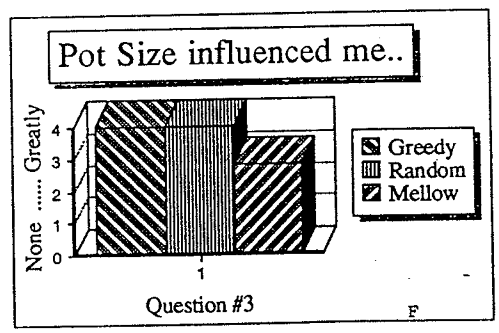


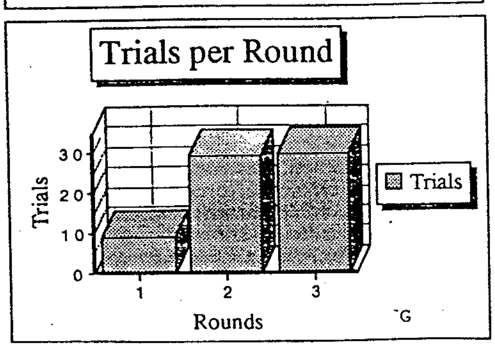












Graphs of Subjects' Behaviors & Perceptions